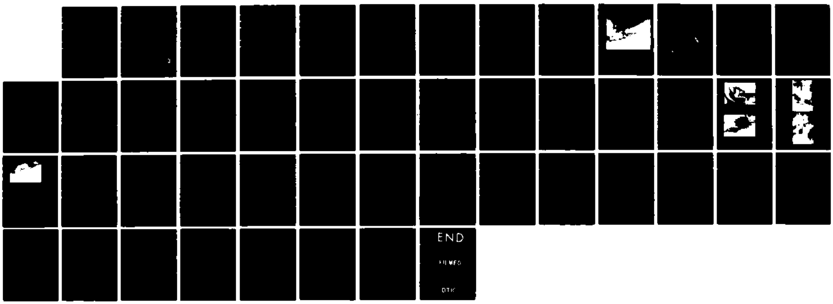
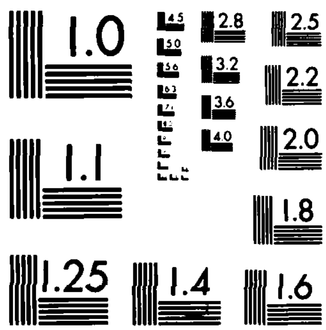
AD-A156 265 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS 1/1
GRAND LAKE DAM (ME 00.. (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV SEP 81

UNCLASSIFIED F/G 13/13 NL





GRAND LAKE DAM
ME 00180

PENOBSCOT RIVER BASIN
GRAND LAKE MATAGAMON

PHASE 1 INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

2

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>ME 00180 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>Grand Lake Dam<br>NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS | | 5. TYPE OF REPORT & PERIOD COVERED<br>INSPECTION REPORT<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>U.S. ARMY CORPS OF ENGINEERS<br>NEW ENGLAND DIVISION | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>DEPT. OF THE ARMY, CORPS OF ENGINEERS<br>NEW ENGLAND DIVISION, NEDED<br>424 TRAPELO ROAD, WALTHAM, MA. 02254 | | 12. REPORT DATE<br>September 1981<br>13. NUMBER OF PAGES<br>25 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Penobscot River Basin
Grand Lake Maragamon

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This dam is a straight-axis, concrete gravity structure 218.5 ft. long and 35 ft. high. It serves as a water storage structure for the Bangor Hydroelectric Co. The spillway is 78 ft. long and contains 9 vertical lift gates 5' high x 7' wide. The dam has 4 10x10 sluice gates plus a 10' wide by 7' high log sluice gate. An unused boiler house in the center of the structure separates the sluice area from the spillway. The watershed classification is "flat and coastal" In event of failure of the dam no homes will be damaged.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

# DISCLAIMER NOTICE

MAIN

CHAS. T. MAIN, INC.
PRUDENTIAL CENTER, BOSTON, MASSACHUSETTS 02199 • TELEPHONE 617-262-3200

September 28, 1981 1345-72-20

SUBJECT: Grand Lake Dam

The Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Attention: E. P. Gould
Project Management Division

Gentlemen:

On November 15, 1979, Grand Lake Dam on the East Branch of the Penobscot River was inspected by Stanley S. Marshall, P.E. and Jan N. Jonas of this office.

Following inspection and subsequent investigation, we concluded that the dam should be reclassified as having a low hazard potential.

Enclosed is a letter report substantiating our finding.

Very truly yours,

CHAS. T. MAIN, INC.

J. E. Giles Jr.

J. E. Giles, Jr.

pel

Enclosure

# TABLE OF CONTENTS

# DESCRIPTION

Grand Lake Dam

The Grand Lake Dam built in 1890 is a straight-axis, concrete gravity structure 218.5' long and 35' high. It serves as a water storage structure for the Bangor Hydroelectric Co. The spillway is 78' long and contains 9 vertical lift gates 5' high x 7' wide. In addition, the dam has 4 10x10 sluice gates plus a 10' wide by 7' high log sluice gate. An unused boiler house in the center of the structure separates the sluice area from the spillway.

A 20' bay on the left abutment contains a fishway designed by the Maine Fish and Game Commission.

## EVALUATION OF HYDROLOGIC AND HYDRAULIC FEATURES

5.1 General - The watershed is 485 square miles of undeveloped rolling terrain and it contains two large lakes, Allapash and Chamberlain. The dam is located on East Branch Penobscot River, on the outlet of Grand Lake Matagamon. The concrete gravity dam develops sufficient storage to reduce the Probable Maximum Flood (PMF) peak from 66370 cfs to 15000 cfs (about 77% reduction).

5.2 Design Data - The dam was designed by the East Branch Improvement Co., Bangor, Maine. The top of the dam elevation is at Elev. 665 with a maximum height of 25 feet (capacity 8200000 ac-ft). This dam is classified as intermediate size. The principal spillway consists of five roller gates. The emergency spillway is equipped with nine sliding gates with total width of 60.3 feet which has a crest elevation of 650 feet.

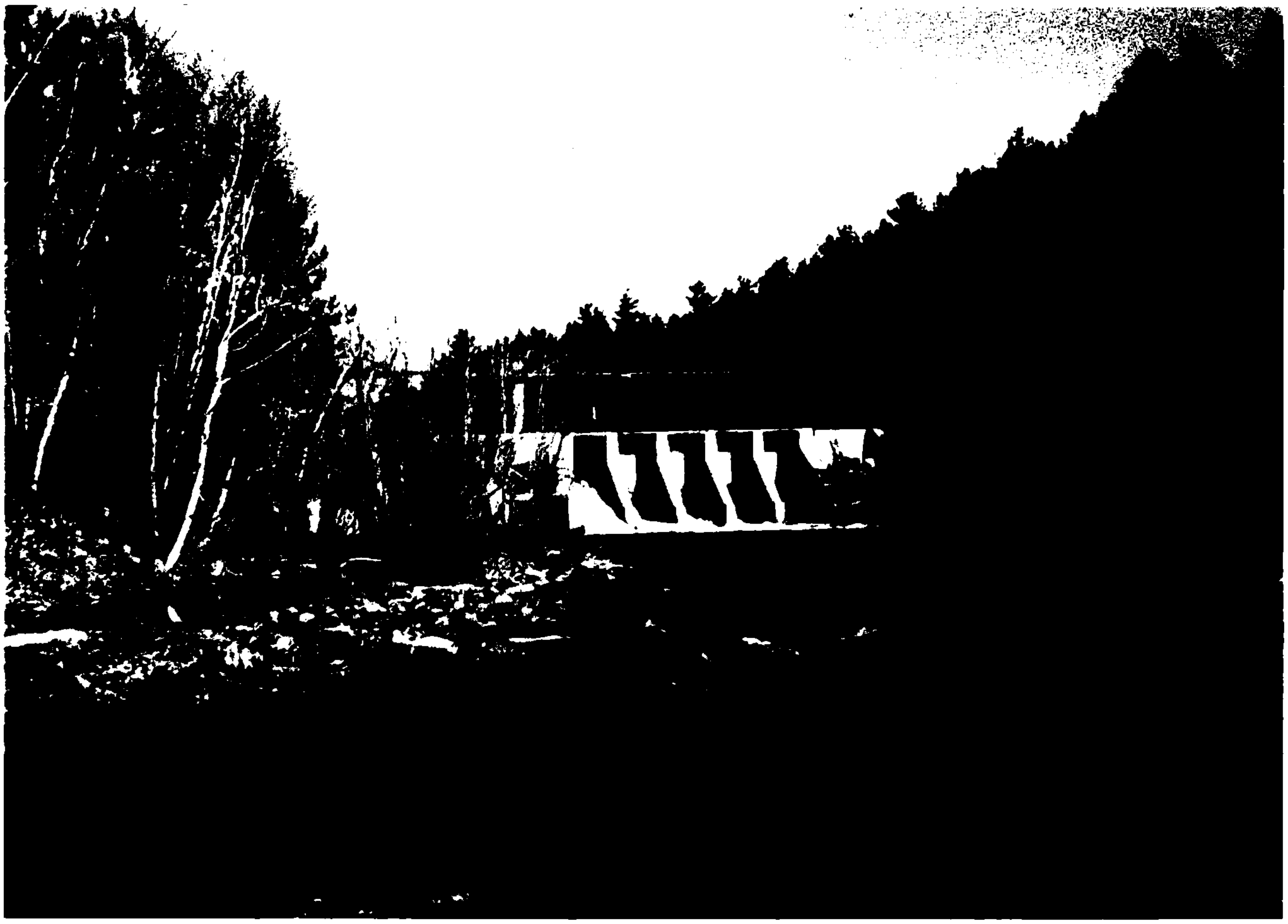
5.3 Experience Data - There are no records of past floods or any overtopping of the dam.

5.4 Test Flood Analysis - Based upon "Preliminary Guidance for Estimating Maximum Probable Discharge", dated March 1978, the watershed classification "flat & coastal" (although the terrain is rolling terrain, due to flood retarding effects of the big lakes in the drainage basin, it is assumed to be flat), and our hydraulic computations, the test flood for this low hazard, intermediate size dam is estimated to be equivalent to the PMF of 66370 cfs. The flood routing starting elevation was selected to be maximum normal pool elevation 655.

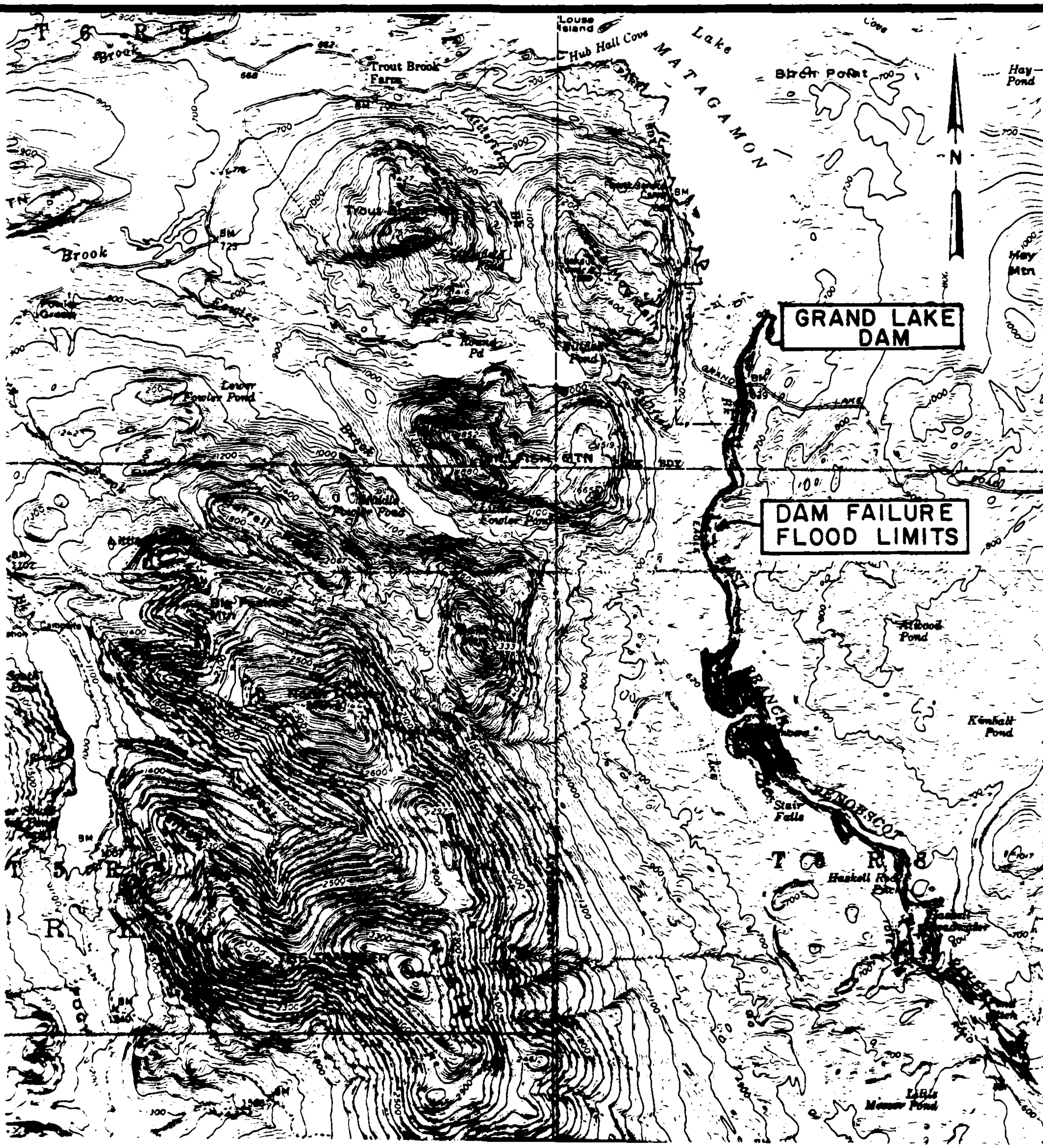
For this particular portion of Maine, the PMF runoff is assumed to be 13". The routed test flood outflow was determined in accordance with Corps of Engineers "Guidance for Estimating Effect of Surcharge Storage on Maximum Probable Discharges", and the hydraulic characteristics of the dam spillway discharge was computed as sharp crested weir. The routed test flood outflow was determined to be approximately 15000 cfs and corresponding water surface elevation 656.3 feet. The top of the dam elevation is 655 feet and thus the dam would not be overtopped.

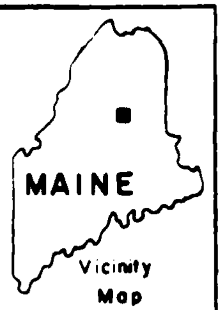
5.5 Dam Failure Analyses - The volume in the reservoir corresponding to the water surface elevation 656.3 (maximum test flood elevation) is 5,265,650 acre-feet which is considered at the time of dam failure. The impact of failure was assessed using the "Rule of Thumb, Guidance for Estimating Downstream Dam Failure Hydrographs" prepared by the Corps of Engin.ers. The breach discharge was estimated with the maximum water surface elevation during PMF event. The breach width was selected to be 35 per-cent of the length of the dam at mid-height. The downstream discharge from the principal and emergency spillways. The total peak discharge was estimated to be 23240 cfs. The result of the calculations included in Appendix D.

In view of these results, it can be concluded that during prefailure and postfailure conditions no homes will be damaged; on the downstream channel no development exists. Thus this dam represents a low hazard structure.



GRAND LAKE DAM




FROM: U.S.G.S. TRAVELER MOUNTAIN, ME. 15 MIN. QUADRANGLE MAP.

1 0 1

SCALE: 1" = 1 MILE

# GRAND LAKE DAM LOCATION MAP

U.S. ARMY CORPS OF ENGINEERS
PHASE I INSPECTION PROGRAM

MAIN

DATE SEPT. 1981

| CLIENT | JOB | PLATE |
|---|---|---|
| 1345 | 72 | |

# APPENDIX A
# CHECKLIST

INSPECTION CHECK LIST

PARTY ORGANIZATION

PROJECT Grand Lake Dam

DATE Nov 15, 1979

TIME 10:00 - 11:30

WEATHER part. cloudy, windy, 29°F

W.S. ELEV. 655 U.S. 641 DN.S.

PARTY:

1. Stanley S. Marshall Civil Eng
2. Jan N. Jonas Civil Eng
3.
4.
5.
6.
7.
8.
9.
10.

| PROJECT FEATURE | INSPECTED BY | REMARKS |
|---|---|---|
| 1. Concrete gravity dam with gated spillway and sluice gates. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |

INSPECTION CHECK LIST

PROJECT Grand Lake Dam DATE Nov 15, 1979

PROJECT FEATURE Concrete gravity dam NAME Stanley S. Marshall

DISCIPLINE Hydro NAME Jan N. Jonas

| AREA EVALUATED | CONDITIONS |
|---|---|
| DAM EMBANKMENT | |
| Crest Elevation | 665 |
| Current Pool Elevation | 655 |
| Maximum Impoundment to Date | not known |
| Surface Cracks | |
| Pavement Condition | not applicable |
| Movement or Settlement of Crest | none visible |
| Lateral Movement | " " |
| Vertical Alignment | good |
| Horizontal Alignment | " |
| Condition at Abutment and at Concrete Structures | " |
| Indications of Movement of Structural Items on Slopes | not applicable |
| Trespassing on Slopes | " " |
| Vegitation on Slopes | " " |
| Sloughing or Erosion of Slopes or Abutments | " " |
| Rock Slope Protection - Riprap Failures | right abutment - good condition |
| Unusual Movement or Cracking at or near Toes | none |
| Unusual Embankment or Downstream Seepage | none |
| Piping or Boils | not applicable |
| Foundation Drainage Features | none visible |
| Toe Drains | none |
| Instrumentation System | none |

INSPECTION CHECK LIST

| | |
|---|---|
| PROJECT Grand Lake Dam | DATE Nov 16, 1979 |
| PROJECT FEATURE Concrete gravity dam | NAME Stanley S. Marshall |
| DISCIPLINE Hydro | NAME Jan N. Jonas |

| AREA EVALUATED | CONDITION |
|---|---|
| OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE | Not applicable |
| a. Approach Channel | |
| Slope Conditions | |
| Bottom Conditions | |
| Rock Slides or Falls | |
| Log Boom | |
| Debris | |
| Condition of Concrete Lining | |
| Drains or Weep Holes | |
| b. Intake Structure | |
| Condition of Concrete | |
| Stop Logs and Slots | |

INSPECTION CHECK LIST

PROJECT Grand Lake Dam

DATE Nov 16, 1979

PROJECT FEATURE Concrete gravity dam

NAME Stanley S. Marshall

DISCIPLINE Hydro

NAME Jan N. Jonas

| AREA EVALUATED | CONDITION |
|---|---|
| OUTLET WORKS - CONTROL TOWER | |
| a. Concrete and Structural | |
| General Condition | good |
| Condition of Joints | visible |
| Spalling | minor at edges and stairs |
| Visible Reinforcing | at stairs and deck slab |
| Rusting or Staining of Concrete | limited areas |
| Any Seepage or Efflorescence | minor efflorescence at sluice gate |
| Joint Alignment | good |
| Unusual Seepage or Leaks in Gate Chamber | not applicable |
| Cracks | minor |
| Rusting or Corrosion of Steel | to a small extent |
| b. Mechanical and Electrical | |
| Air Vents | not applicable |
| Float Wells | not applicable |
| Crane Hoist | working condition |
| Elevator | not applicable |
| Hydraulic System | " " |
| Service Gates | wood slide gates in working cond. |
| Emergency Gates | " " " " " |
| Lightning Protection System | |
| Emergency Power System | diesel aggregate in adjoining wood house is used for regular operation |
| Wiring and Lighting System in Gate Chamber | not applicable |

INSPECTION CHECK LIST

PROJECT Grand Lake Dam

DATE Nov 16, 1979

PROJECT FEATURE Concrete gravity dam

NAME Stanley S. Marshall

DISCIPLINE Hydro

NAME Jan N. Jonas

| AREA EVALUATED | CONDITION |
|---|---|
| OUTLET WORKS - TRANSITION AND CONDUIT | not applicable |
| General Condition of Concrete | |
| Rust or Staining on Concrete | |
| Spalling | |
| Erosion or Cavitation | |
| Cracking | |
| Alignment of Monoliths | |
| Alignment of Joints | |
| Numbering of Monoliths | |

INSPECTION CHECK LIST

PROJECT *Grand Lake Dam* DATE *Nov 16, 1979*

PROJECT FEATURE *Concrete gravity dam* NAME *Stanley S. Marshall*

DISCIPLINE *Hydro* NAME *Jan N. Jonas*

| AREA EVALUATED | CONDITION |
|---|---|
| OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL | |
| General Condition of Concrete | *satisfactory, showing minor damage due to frost* |
| Rust or Staining | *none* |
| Spalling | *minor, limited* |
| Erosion or Cavitation | *none* |
| Visible Reinforcing | *none* |
| Any Seepage or Efflorescence | *none* |
| Condition at Joints | *good* |
| Drain holes | *none visible* |
| Channel | *natural river channel with rocky bottom* |
| Loose Rock or Trees Overhanging Channel | *none* |
| Condition of Discharge Channel | *satisfactory* |

INSPECTION CHECK LIST

PROJECT Grand Lake Dam DATE Nov 16, 1979

PROJECT FEATURE Concrete gravity dam NAME Stanley S. Marshall

DISCIPLINE Hydro NAME Jan N. Jonas

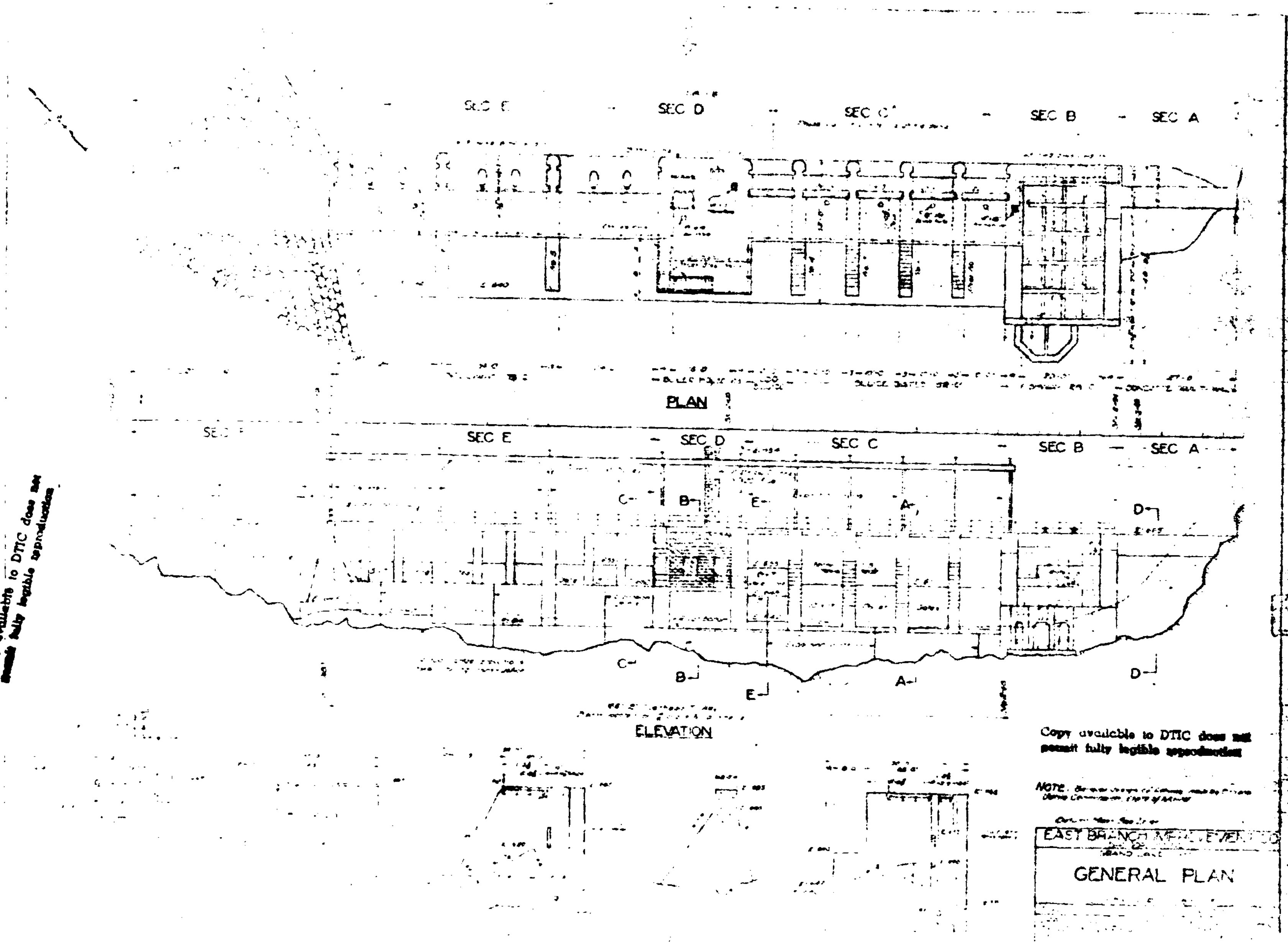
| AREA EVALUATED | CONDITION |
|---|---|
| OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS | |
| a. Approach Channel | Not applicable |
| General Condition | |
| Loose Rock Overhanging Channel | |
| Trees Overhanging Channel | |
| Floor of Approach Channel | |
| b. Weir and Training Walls | |
| General Condition of Concrete | satisfactory |
| Rust or Staining | minor rusting |
| Spalling | minor spalling at edges |
| Any Visible Reinforcing | none |
| Any Seepage or Efflorescence | negligible |
| Drain Holes | none visible |
| c. Discharge Channel | natural river bed |
| General Condition | |
| Loose Rock Overhanging Channel | |
| Trees Overhanging Channel | |
| Floor of Channel | |
| Other Obstructions | |

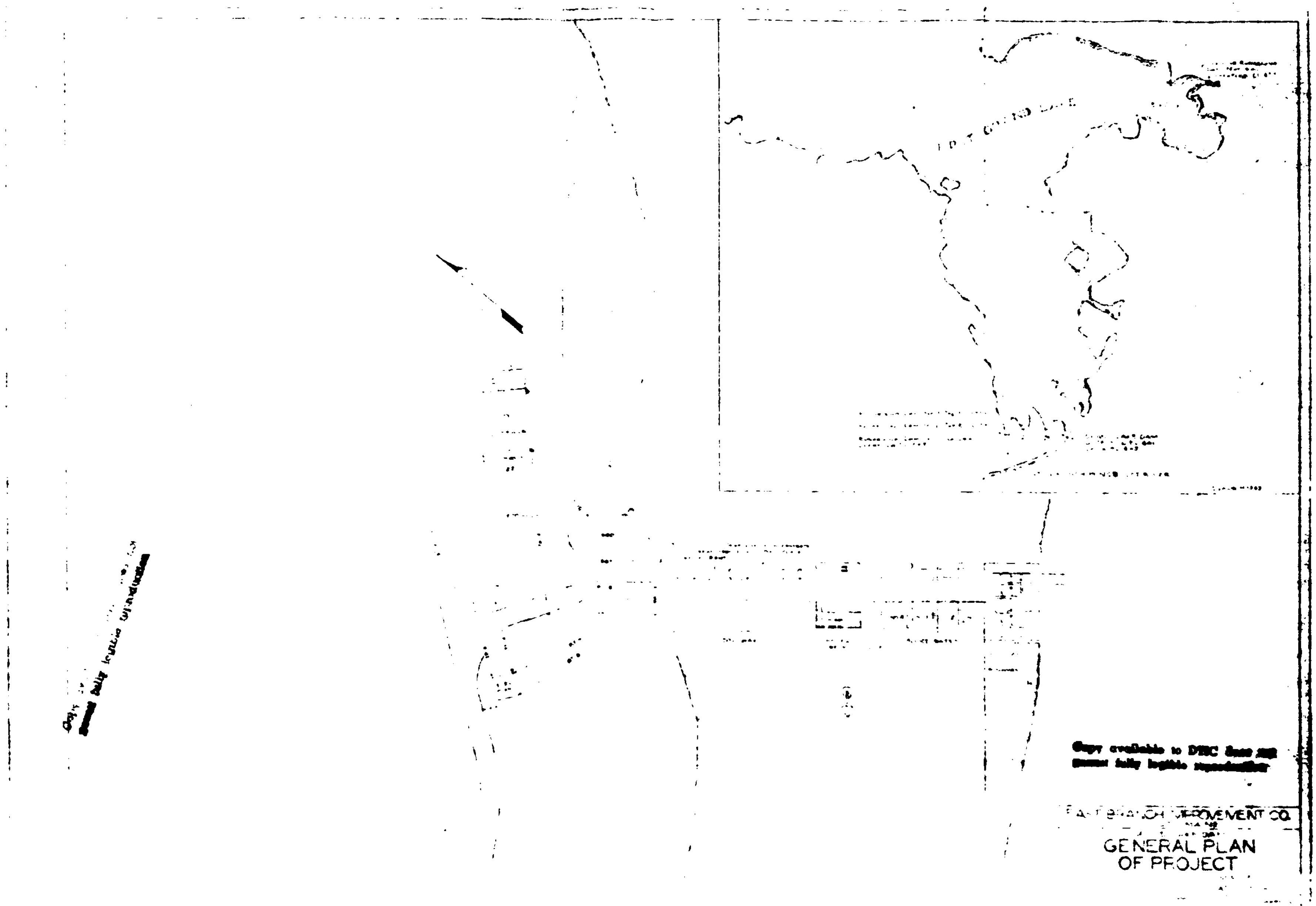
INSPECTION CHECK LIST

| | |
|---|---|
| PROJECT Grand Lake Dam | DATE Nov 16, 1979 |
| PROJECT FEATURE Concrete gravity dam | NAME Stanley S. Marshall |
| DISCIPLINE Hydro | NAME Jan N. Jonas |

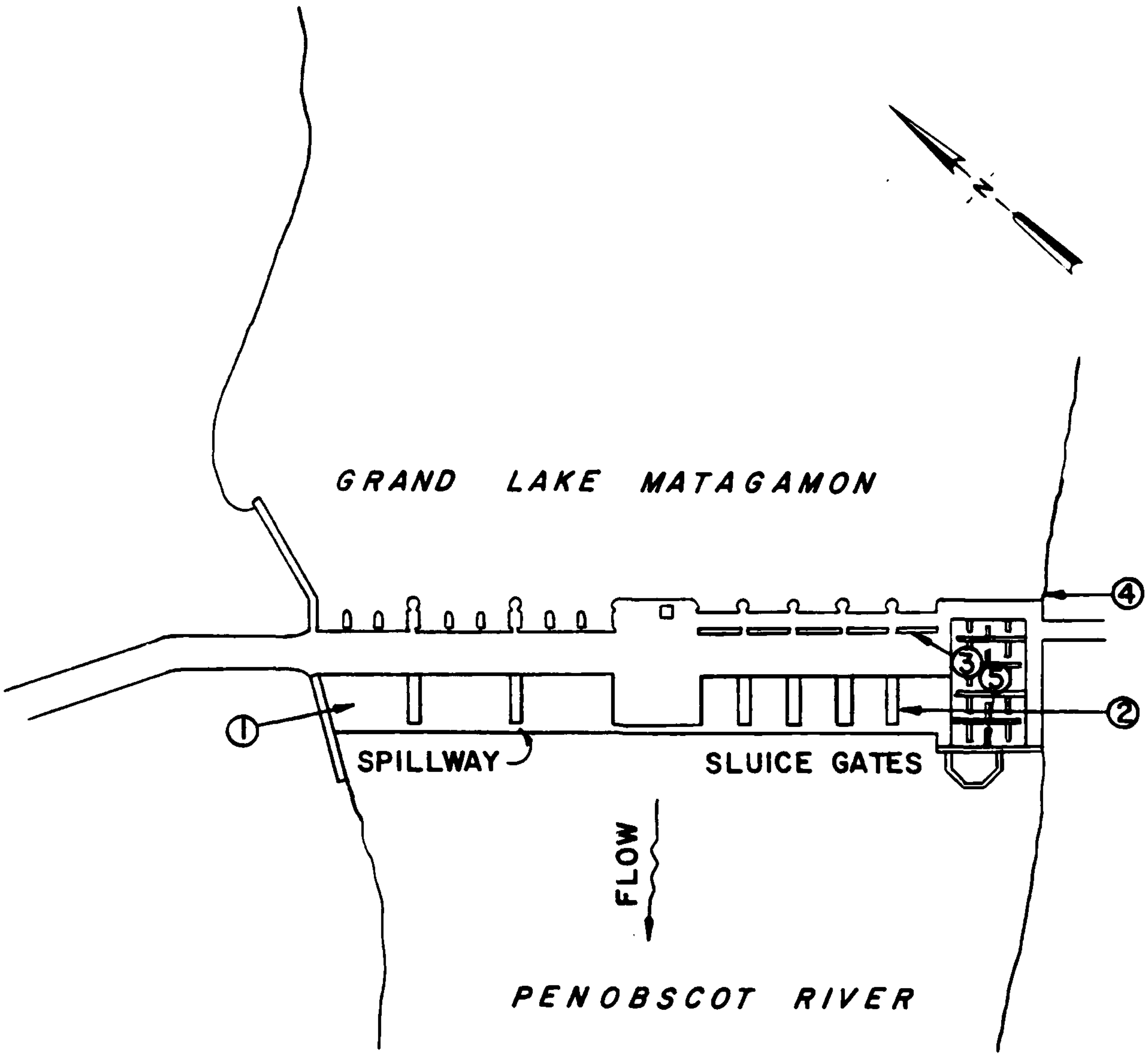
| AREA EVALUATED | CONDITION |
|---|---|
| OUTLET WORKS - SERVICE BRIDGE | Not applicable |
| a. Super Structure | |
| Bearings | |
| Anchor Bolts | |
| Bridge Seat | |
| Longitudinal Members | |
| Under Side of Deck | |
| Secondary Bracing | |
| Deck | |
| Drainage System | |
| Railings | |
| Expansion Joints | |
| Paint | |
| b. Abutment & Piers | |
| General Condition of Concrete | |
| Alignment of Abutment | |
| Approach to Bridge | |
| Condition of Seat & Backwall | |

# APPENDIX B
# ENGINEERING DATA


SEC E
SEC D
SEC C
SEC B
SEC A
PLAN
ELEVATION
EAST BRANCH
GENERAL PLAN


IMPROVEMENT CO.
GENERAL PLAN
OF PROJECT

# APPENDIX C
# PHOTOGRAPHS




# GRAND LAKE DAM
# PHOTO LOCATION MAP

U.S. ARMY CORPS OF ENGINEERS
PHASE I INSPECTION PROGRAM

DATE SEPT. 1981

MAIN

| CLIENT | JOB | PLATE |
|---|---|---|
| 1345 | 72 | |

Fig. 1 Downstream view of dam from right bank. Note fish ladder at left embankment

Fig. 2 Downstream view of dam from left bank.Stairs in center of picture lead to abandonned boiler house.

Fig. 3 Chain supporting spillway slide gate. Note dogging device.

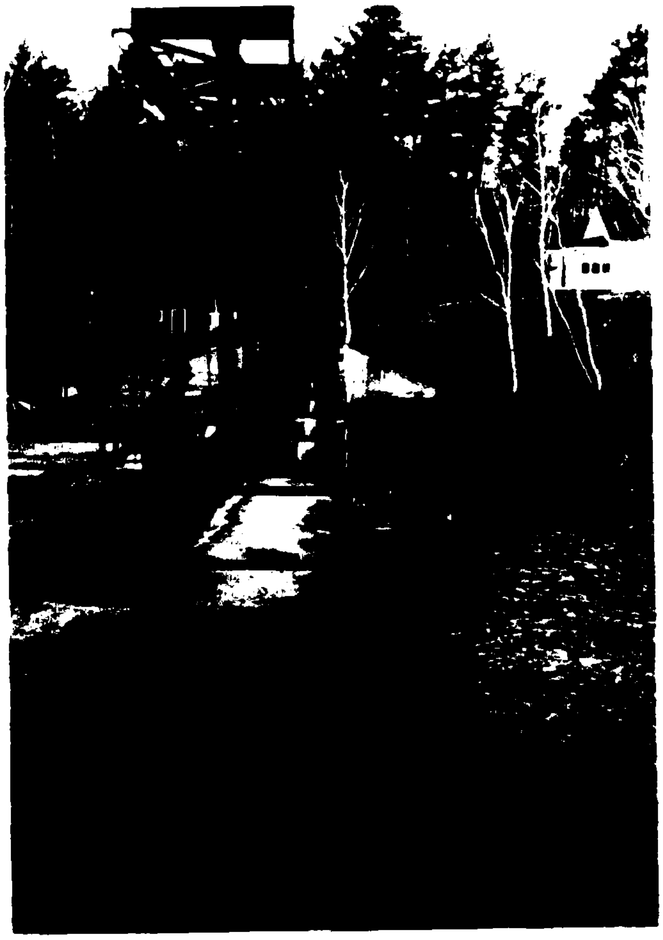


Fig. 4 Upstream view of dam from left abutment. Wheel operated gates in foreground are for fishway.

Fig. 5 Downstream entrance to fishway.

# APPENDIX D
# HYDROLOGIC AND HYDRAULIC COMPUTATIONS

# MAIN

Client: CORPS OF ENGINEERS — Job No. 1345-072 — Sheet 1 of 18

Subject: GRAND LAKE DAM — By T. OTSUKA — Date 03-IX-1981

HYDROLOGY – HYDRAULICS — Ckd. — Rev.

Although Grand Lake Basin is located inland, because it contains two large lakes ( Allagash Lake, Chamberlain Lake), excluding Grand Lake Matagamon), the curve for Flat & Coastal terrain of the PMF Curves (Corps of Engineers Guidelines, March 1978) was used in estimating peak discharge. For drainage area of 485 square miles this curve shows 200 cfs/sq.mi of unit peak discharge.

The total peak discharge = 485 × 200 = 97000 CFS.
The Guideline Curves are derived for 19" runoff. In this part of New England, Maine, Depth-Area-Duration curves show a 13" of runoff and this is confirmed by the Corps of Engineers.
Then, test flood is assumed to be equal to PMF which its peak is,

$$Q_{test} = 97000 \times \frac{13}{19} = 66\,368 \text{ CFS.}$$

MAIN

Client CORPS OF ENGINEERS Job No. 1345-072-4 Sheet 2 of 18
Subject GRAND LAKE DAM By T. OTOVA Date 24-IX-1981
HYDROLOGY - HYDRAULICS Ckd. Rev.

There are two kind of spillways in the Grand Lake Dam:

1.- Roller Gates (5 number),

2.- Sliding Gate (4 number).

Their rating curves are presented in pages 4 and 5, respectively.

The rating curve of total discharges, and for the discharges occurring only above elevation 655 are also shown in page 8.

The Area-Capacity curves are estimated from 1:62,500 scale topographic maps and by using logarithmic curve fitting procedure (pages 9, 10 and 11).

The effects of surcharge storage on maximum probable discharges are estimated according to Corps of Engineers' procedure presented in the previous pages. Calculations are shown in page 12.

RESULTS: Due to very large size of the Grand Lake, the reservoir level will rise 1.3 ft. during a test flood event.

MAIN

Client CORPS OF ENGINEERS Job No. 1345-072 Sheet 3 of 18
Subject GRAND LAKE DAM By T. OTOVA Date 03-IX-1981
HYDROLOGY – HYDRAULICS Ckd. Rev.

FIVE ROLLER GATES

RATING CURVE

$$Q = C \times L \times H^{3/2}$$

Q is discharge cfs

C is discharge coefficient = 3.9

L is total length in ft.

H is surcharge ft.

$L = 10 \times 5 = 50$ ft.

$$Q = 3.9 \times 50 \times H^{3/2} = 195\ H^{3/2}$$

The rating curve is presented in the next page.

The crest elevation = 641.

MAIN

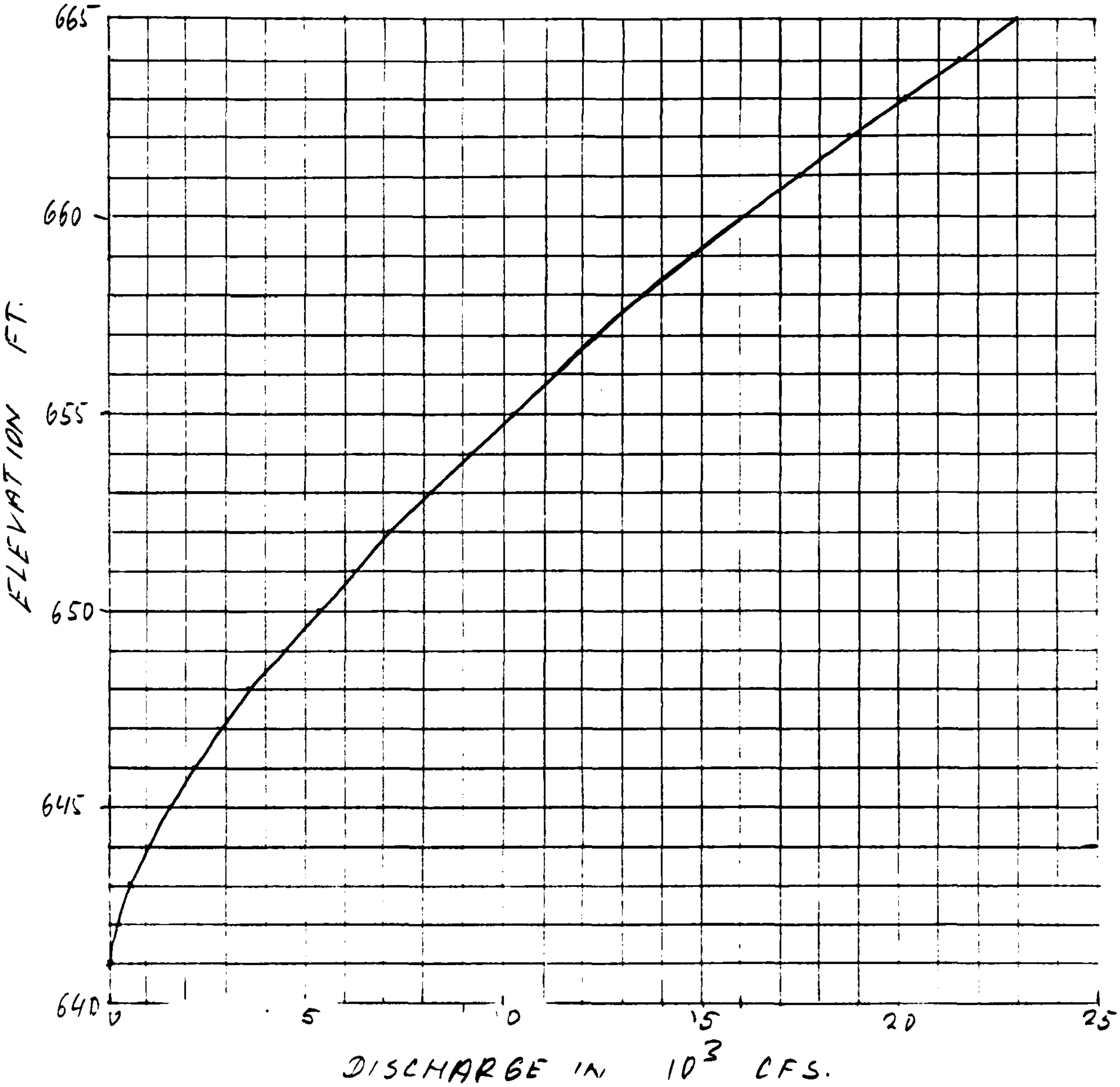
Client CORPS OF ENGINEERS Job No. 1345-072 Sheet 4 of 18

Subject GRAND LAKE DAM By T. OTOVA Date 03-IX-1981

HYDROLOGY - HYDRAULICS Ckd. Rev.

FIVE ROLLER GATES

RATING CURVE:



**MAIN**

Client: CORPS OF ENGINEERS — Job No. 1345-072-4 — Sheet 5 of 18

Subject: GRAND LAKE DAM — By: T. OTOVA — Date: 03-IX-1981

HYDROLOGY – HYDRAULICS — Ckd. — Rev.

NINE SLIDING GATES

RATING CURVE

$$Q = C \times L \times H^{3/2}$$

$$L = 9 \times 6.7 = 60.3 \text{ FT.}$$

$$Q = 3.9 \times 60.3 \times H^{3/2} = 235.2\ H^{3/2}$$

The crest elevation is 650 FT.

The rating curve is presented in the next page.

MAIN

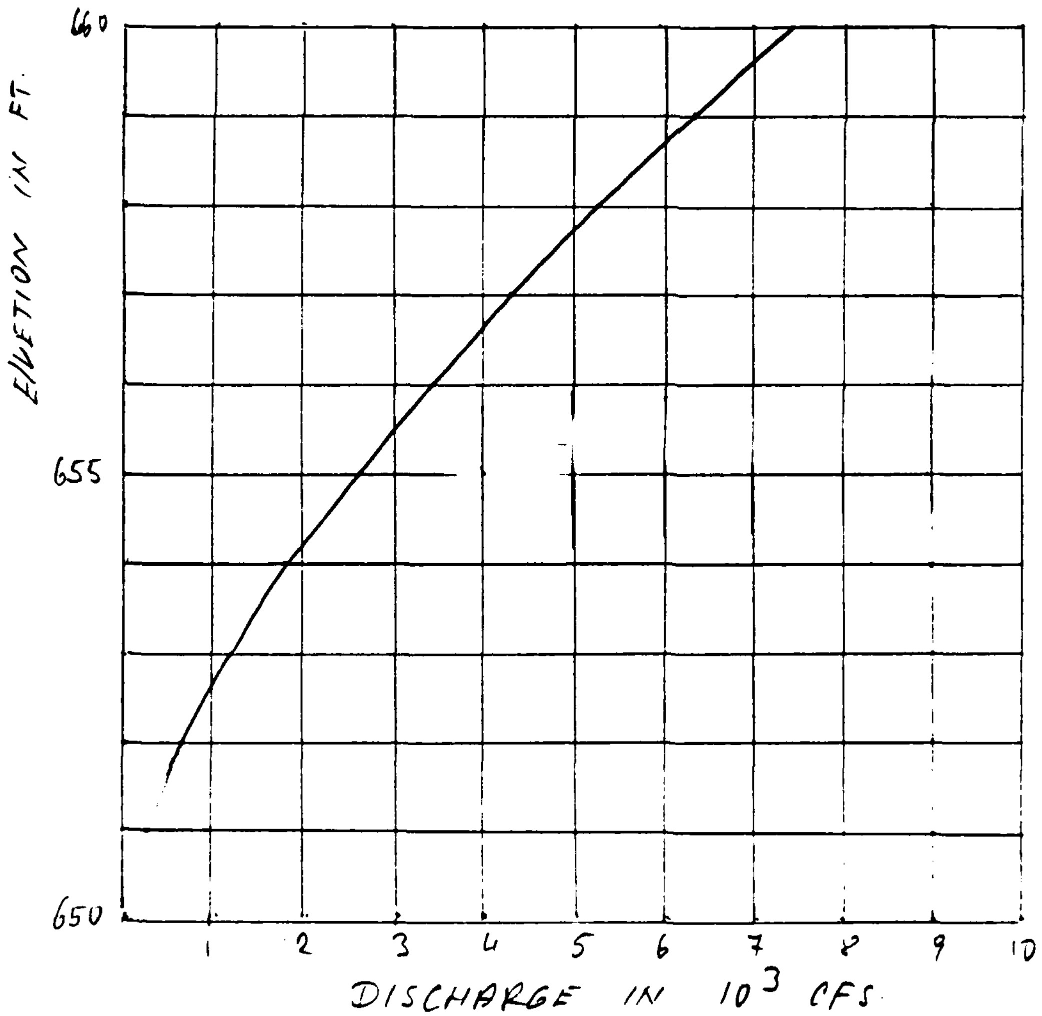
Client CORPS OF ENGINEERS Job No. 1345-072-4 Sheet 6 of 18

Subject GRAND LAKE DAM By T. OTOVA Date 03-IX 1981

HYDROLOGY - HYDRAULICS Ckd. Rev.

NINE SLIDING GATES

RATING CURVE:



**MAIN**

Client: CORPS OF ENGINEERS — Job No. 1345-072 — Sheet 7 of 18
Subject: GRAND LAKE DAM — By T. OTOVA — Date 03-IX-1981
HYDROLOGY - HYDRAULICS — Ckd. — Rev.

TOTAL RATING CURVE

FOR ROUTING STARTING ELEVATION 655 (Maximum Normal Pool Elevation).

Total Discharge at Elv. 655:

- From 5 roller gates: 10 220 CFS
- From 9 sliding gates: 2 630 CFS

Total 12 850 CFS.

Discharge Formula:

$$Q = C \times L \times H^{3/2}$$

$$Q = 3.9 \times (235.2 + 195.0) \times H^{3/2}$$

$$Q = 1677.8\ H^{3/2} + 12850$$

$$H = (0.0005960186 \times Q - 7.658838956)^{2/3}$$

Routing Starting Elev. 655

The rating curve is presented in the next page.

Additional Discharges above Elv. 655 can be presented as $Q = 1677.8\ H^{3/2}$

and surcharge formula becomes

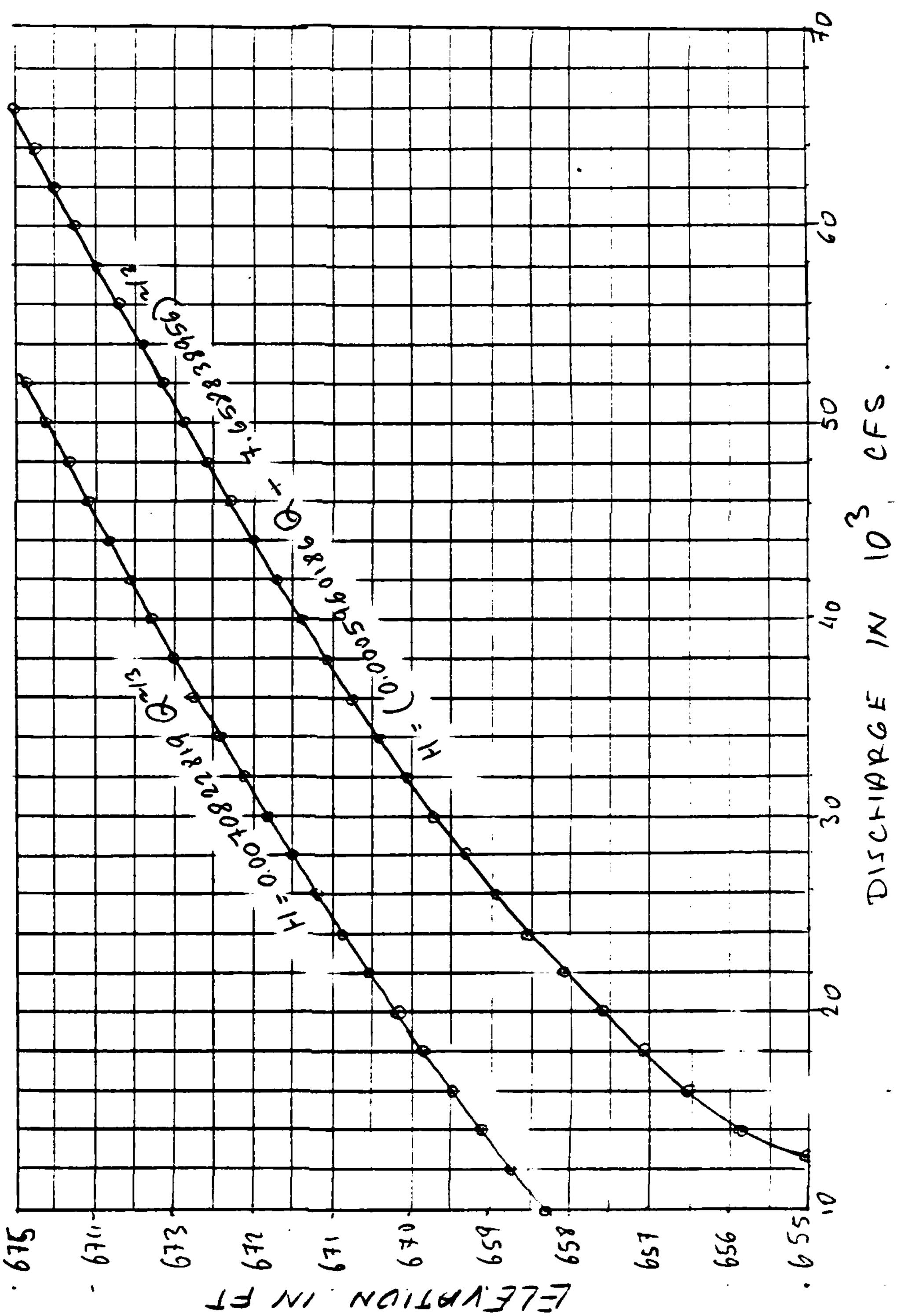
$$H = 0.00708 22819\ Q^{2/3}$$

**MAIN**

Client CORPS OF ENGINEERS Job No. 1345-072-4 Sheet 8 of 18

Subject GRAND LAKE DAM By T. OTOUA Date 03-IX-1981

HYDROLOGY - HYDRAULICS Ckd. Rev.



MAIN

Client CORPS OF ENGINEERS Job No. 1345-072-4 Sheet 9 of 18

Subject GRAND LAKE DAM By T. OTOUKA Date 02-IX-1981

HYDROLOGY - HYDRAULICS Ckd. Rev.

CORPS OF ENGINEERS

GRAND LAKE DAM AREA CURVE

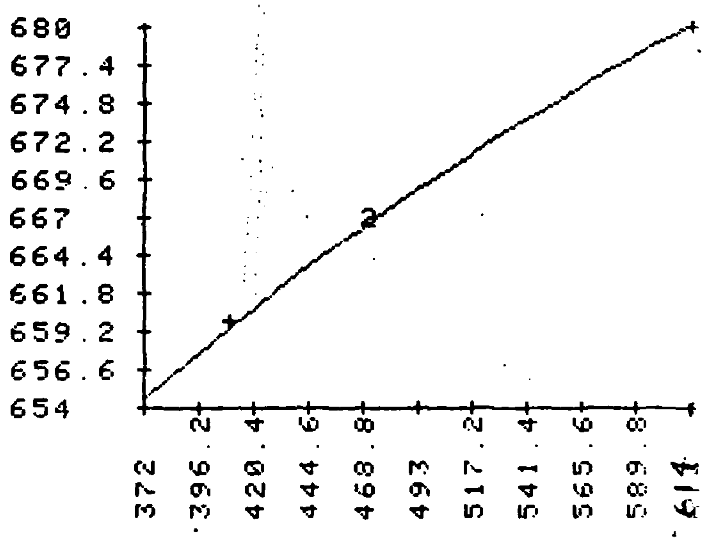
| I | X(I) | Y(I) |
|---|---|---|
| 1 | 372.0000 | 654.0000 |
| 2 | 409.0000 | 660.0000 |
| 3 | 614.0000 | 680.0000 |

AOV: LOG REG:CODE 2

| SOURCE/DF | | SS | MS | F |
|---|---|---|---|---|
| TOTAL | 2 | 370.7 | | |
| REG | 1 | 370.0 | 370.0 | 536.9 |
| RESID | 1 | 0.7 | 0.7 | |

R SQUARE = 0.998

YHAT= 352.094+ 51.094LOG X



**MAIN**

Client: CORPS OF ENGINEERS — Job No. 1345-072-4 — Sheet 10 of 18

Subject: GRAND LAKE DAM HYDROLOGY - HYDRAULICS — By T. OTOVA — Date 02-IX-1981

Ckd. ___ Rev. ___

CORPS OF ENGINEERS

GRAND LAKE DAM CAPACITY CURVE

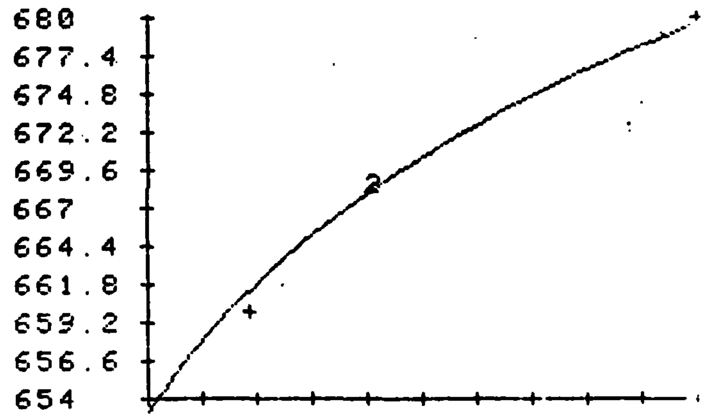
| I | X(I) | Y(I) |
|---|---|---|
| 1 | 4466760.0000 | 654.0000 |
| 2 | 6811152.0000 | 660.0000 |
| 3 | . | 680.0000 |

AOV: LOG REG:CODE 2

| SOURCE/DF | | SS | MS | F |
|---|---|---|---|---|
| TOTAL | 2 | 370.7 | | |
| REG | 1 | 367.6 | 367.6 | 120.2 |
| RESID | 1 | 3.1 | 3.1 | |

R SQUARE = 0.992

YHAT= 349.892+ 19.798LOG X



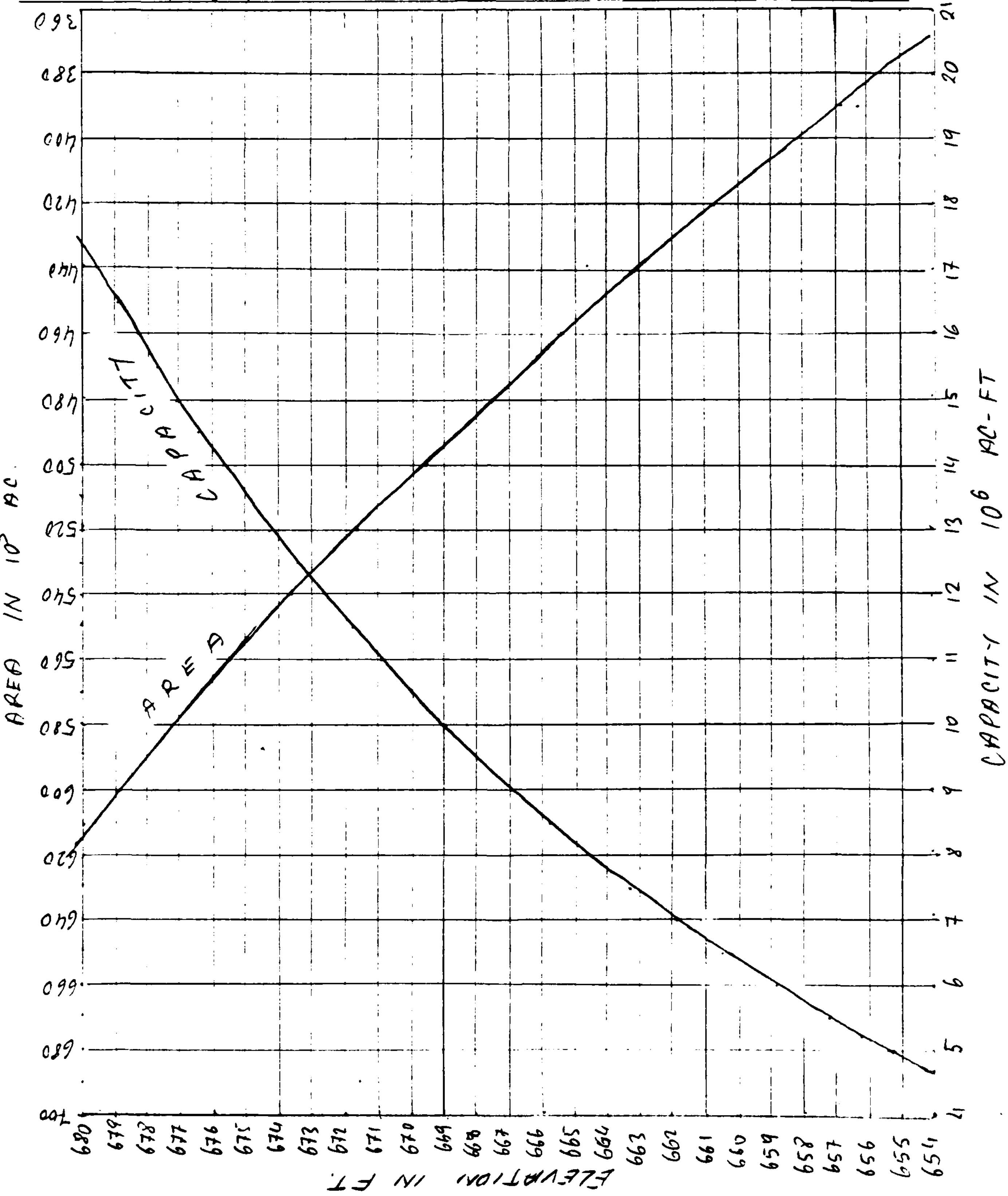

XMIN=4466760 :TICS=1258099.2

MAIN

Client CORPS OF ENGINEERS Job No. 1345-072-4 Sheet 11 of 18

Subject GRAND LAKE DAM By J. OTOVA Date 02-IX-81

HYDROLOGY - HYDRAULICS Ckd. Rev.



**MAIN**

Client CORPS OF ENGINEERS | Job No. 1345-072 | Sheet 12 of 18

Subject GRAND LAKE DAM | By T. OTOVA | Date 02-IX-1981

HYDROLOGY - HYDRAULICS | Ckd. | Rev.

## ESTIMATING

## EFFECT OF SURCHARGE STORAGE

## ON MAXIMUM PROBABLE DISCHARGES

These calculations are performed according to the Corps of Engineers Guidelines

GRAND LAKE DAM

### D A T A :

DRAINAGE AREA,
A= 485 (sq.mi.)

PEAK INFLOW,
Qp1= 66368 (cfs)

PRINCIPAL SPILLWAY CREST ELEV.,
ELV1= 655 (ft.)

EMERGENCY SPILLWAY CREST ELEV.,
ELV2= 656.3 (ft.)

Emergency Spillway Rating Curve is defined as ,

H = a * Q ^ b

a = .0070822819
b = .666666666667

The Capacity - Elv. curve is defined as,

Elv = m + n * Log(Volume)

m= 349.892
n= 19.798

TOTAL PMF RUNOFF,
R= 13 (in.)

### CALCULATIONS:

### S T E P 1

Reduction of the Qp1 due to starting elevation at Principal Spillway crest elev.

Volume at 655 (ft.)

Volume1 =Exp((ELV1-m)/n)
Volume1 = 4930996.332 (ac-ft)

Volume at 656.3 (ft.)

Volume2 =Exp((ELV2-m)/n)
Volume2 = 5265648.246 (ac-ft)

Diff. of Volumes,

Diff.Volume = 334651.914 (ac-ft)
or,
Diff.Volume, D= 12.93 (in.)

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Client CORPS OF ENGINEERS Job No. 1345-072 Sheet 13 of 18

Subject GRAND LAKE DAM By T. OTOVA-4 Date 04-IX-1981

HYDROLOGY - HYDRAULICS Ckd. Rev.

DAM FAILURE ANALYSES:

The reservoir water elevation is assumed to be at the top of the sliding gates (Elv. 656.3) prior the failure of the dam. The five roller gates are assumed to be open and their total discharge of 10000 CFS is assumed as the test flood discharge during prefailure conditions.

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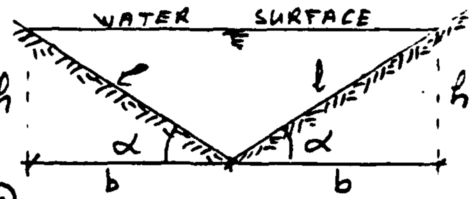
Client: CORPS OF ENGINEERS — Job No. 1345-072-4 — Sheet 14 of 18

Subject: GRAND LAKE DAM — By: T. OTOVA — Date: 04-IX-1981

HYDROLOGY – HYDRAULICS — Ckd. — Rev.

## DERIVATION OF STAGE – DISCHARGE RELATIONSHIP

The flood plain is assumed to have a triangular shape, for simplification reason.




Area, $A = \frac{h \times b}{2} \times 2 \qquad A = h \times b$

$\frac{h}{b} = \tan\alpha \qquad b = \frac{h}{\tan\alpha} \qquad \boxed{A = \frac{h^2}{\tan\alpha}}$ (I)

Wetted Parameder, W,

$W = 2l \qquad \frac{b}{l} = \cos\alpha \qquad l = \frac{b}{\cos\alpha} \qquad \boxed{W = \frac{2b}{\cos\alpha}}$ ... (II)

Hydraulic Radius; R,

$R = \frac{A}{W} = \frac{bh}{2\frac{b}{\cos\alpha}} = \frac{h}{2} \times \cos\alpha \qquad \boxed{R = \frac{h\cos\alpha}{2}}$ ... (III)

Manning's Formula, $Q = \frac{1.49 \times A \times R^{2/3} \times S^{1/2}}{m}$

S is the channel slope
m is the roughness coefficient

By substituting in the formula A, R by the formulas I and II,

$$Q = \frac{1.49}{m} \times \frac{h^2}{\tan\alpha} \times \left(\frac{h \times \cos\alpha}{2}\right)^{2/3} \times S^{1/2} = \frac{1.49}{m} \times \frac{S^{1/2}}{\tan\alpha} \times \frac{(\cos\alpha)^{2/3}}{2^{2/3}} \times h^{8/3}$$

then,

$$h = \left[\frac{m \times \tan\alpha \times 2^{2/3}}{1.49 \times (\cos\alpha)^{2/3} \times S^{1/2}} \times Q\right]^{3/8}$$

or,

$$\boxed{h = \frac{1.066 \times m \times \tan\alpha}{(\cos\alpha)^{2/3} \times S^{1/2}} \times Q}$$ ... (IV)

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Client CORPS OF ENGINEERS Job No. 1345-072 Sheet 15 of 18
Subject GRAND LAKE DAM By T. OTOVIA Date 04-IX-1981
HYDROLOGY - HYDROLICS Ckd. Rev.

GRAND LAKE
DAM FAILURE ANALYSES
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These calculations are performed according to the RULE OF THUMB procedures of the Corps of Engineers

The breach discharge:
Qp1 = 8/27 * Wb * g^0.5 * Yo^3/2

Where,

Yo is the height of the breach ( from river bed to the max. pool level)

Wb is 35% of the length of the dam, or Wb = .35 * Wd

g is the acceleration of the gravity ( 32.2 ft/sec^2 )

Yo = 16.3 (ft)

Wd = 213 (ft)

Wb = 74 (ft)

From above equation,
Qp1 = 8248 (cfs)

The natural channel cross sections are simplyfied as triangular cross sections

The stage-discharge relationship becomes as,

h = [ 1.068 * n * Tan(a) * Q / Cos(a)^2/3 / S^.5 ]^3/8....(I)

Where,

Q = Discharge (cfs)
a = Side slope angle (deg)
S = Channel slope

The cross section Area:

A = h^2 / Tan(a) ....(II)

The Volume of the Reservoir,
V = 5265648 (ac-ft)
or,
V = 229371626880 (cub-ft)

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Client CORPS OF ENGINEERS Job No. 1345-072-4 Sheet 16 of 18

Subject GRAND LAKE DAM By T. PTOVA Date 04-IX-1983

HYDROLOGY - HYDRAULICS Chkd. ______ Rev. ______

R E A C H ( 1 ) CALCULATIONS

Test flood discharge:
Qt = 15000 (cfs)

a = 2.17 (deg.)
S = .00193
n = .07
L = 4000 (ft)

From Formula (I),

Prefailure height,

h1 = 13.1 (ft)

From Formula (II) ,

A1 = 4578 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 15.5 (ft)

From Formula (II),
Total Area,
A = 6360 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 1781 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 7126306 (cub-ft)

Qp2 = Qp1 * ( 1 - V1 / V)

Qp2 = 8248 (cfs)

From Formula (I),

Q=Qp2+Qt

h = 15 (ft)

From Formula (II),

A = 6360 (ft)

Residual Area,

A2 = A - A1

A2 = 1781 (ft)

V2 = A2 * L

V2 = 7126096 (cub-ft)

Vavg = ( V1 + V2 ) / 2

Vavg = 7126201 (cub-ft)

Qp2 = Qp1 * ( 1 - Vavg / V )

Qp2 = 8248 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 15.5 (ft)

RESULTS :

1.) Prefailure Height = 13.1 (ft)

2.) Postfailure Height = 15.5 (ft)

3.) Breach Discharge = 8248 (cfs)

4.) Reach Length = 4000 (ft)

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Client CORPS OF ENGINEERS Job No. 1345-072 Sheet 17 of 18
Subject GRAND LAKE DAM By J. OTUJH Date 04-IX-1982
HYDROLOGY - HYDRAULICS Ckd. Rev.

## REACH ( 2 ) CALCULATIONS

Test flood discharge:
Qt = 15000 (cfs)

a = 1.35 (deg.)
S = .00193
n = .07
L = 15700 (ft)

From Formula (I),

Prefailure height,

h1 = 11 (ft)

From Formula (II) ,

A1 = 5154 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 12.9 (ft)

From Formula (II),
Total Area,
A = 7160 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 2005 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 31489022 (cub-ft)

Qp2 = Qp1 * ( 1 - V1 / V)

Qp2 = 8247 (cfs)

From Formula (I),

Q=Qp2+Qt

Q = 23247 (cfs)

h = 12 (ft)

From Formula (II),

A = 7160 (ft)

Residual Area,

A2 = A - A1

A2 = 2005 (ft)

V2 = A2 * L

V2 = 31484915 (cub-ft)

Vave = ( V1 + V2 ) / 2

Vave = 31486968 (cub-ft)

Qp2 = Qp1 * ( 1 - Vave / V )

Qp2 = 8247 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 12.9 (ft)

## RESULTS :

1.) Prefailure Height = 11 (ft)

2.) Postfailure Height = 12.9 (ft)

3.) Breach Discharge = 8247 (cfs)

4.) Reach Length = 15700 (ft)

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Client CORPS OF ENGINEERS — Job No. 1345-072 — Sheet 18 of 18

Subject GRAND LAKE DAM — By T.OTOVA — Date 04-IX-1981

HYDROLOGY - HYDRAULICS — Ckd. — Rev.

R E A C H ( 3 ) CALCULATIONS

Test flood discharge:
Qt = 15000 (cfs)

a = 1.76 (deg.)
S = .0033
n = .07
L = 12000 (ft)

From Formula (I),

Prefailure height,

h1 = 11 (ft)

From Formula (II) ,

A1 = 3945 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 12.9 (ft)

From Formula (II),
Total Area,
A = 5480 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 1534 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 18418692 (cub-ft)

Qp2 = Qp1 * ( 1 - V1 / V)

Qp2 = 8246 (cfs)

From Formula (I),

Q=Qp2+Qt

Q = 23246 (cfs)

h = 12 (ft)

From Formula (II),

A = 5480 (ft)

Residual Area,

A2 = A - A1

A2 = 1534 (ft)

V2 = A2 * L

V2 = 18417286 (cub-ft)

Vavg = ( V1 + V2 ) / 2

Vavg = 18417989 (cub-ft)

Qp2 = Qp1 * ( 1 - Vavg / V )

Qp2 = 8246 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 12.9 (ft)

RESULTS :

1.) Prefailure Height = 11 (ft)

2.) Postfailure Height = 12.9 (ft)

3.) Breach Discharge = 8246 (cfs)

4.) Reach Length = 12000 (ft)

# APPENDIX E
# INVENTORY FORMS

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